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MICROSCOPIC FORMS OBSERVED IN WATER OF LAKE ERIE.

By C. M. Vorce, F. R. M. S., Cleveland, Ohio.

The observations recorded in the plate and list of figures accompanying this paper, are the result of a continuation of the work mentioned in my paper of last year, read before this Society,* the same methods and source of supply being employed. The period covered by these observations is from March 6th to July 12th, 1882, embracing all of the spring period and the early part of the summer period, as defined in the paper of last year above referred to, and the forms observed which are not figured in the plate accompanying that paper are figured in the plate forming part of this communication, and nearly all of these forms were also observed during the corresponding period of last year.

It would be preferable to make a continuous series of examinations covering one or more years, and to figure or enumerate the forms continuously in their season, but in my own case this is not practicable, hence I have been compelled to content myself with devoting, so far, an entire year, or nearly that, to the forms of a single period.

No facts of especial significance have been developed by the observations herein recorded, which merely serve to further illustrate the facts and views set forth in the previous paper. Nevertheless, a change, although slight, is apparent between the prevalent forms of the present and of a corresponding period four or five years ago, the cause of which may, or may not, have an important public interest.

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* Proceedings Amer. Soc. Mic., p. 51-60.

Among the forms now common in spring and abundant in summer and fall, and which, a few years ago, were rare in spring and but moderately common in summer and fall, are several species of *Infusoria*, representing the families *Oxytrichina*, *Bursarina* and *Vorticellina* (C. and L.), while the *Actinophryna*, formerly always rare, have become not uncommon.

The forms of *Vorticella*, figures 4, 6, 149, plate VII., Proc. 1881, were, until lately, almost the sole representatives of the family, and were most plentiful in the late winter and early spring gatherings, being apparently scarce in summer, although seen occasionally throughout the year. One by one, new forms of this genus have appeared, usually in the warmer months, until now the observer, in a week's work, will be likely to meet with a dozen or more species, varieties, or conditions of *Vorticella*. During the summer of 1881 the species (figure 2, plate III.) was frequently observed, although never numerous, while during the latter part of June, 1882, it was so excessively abundant that, for several days in succession, every dip yielded scores of the clusters, invariably located upon bunches of *Anabæna*. The forms of *Oxytrichina* and *Bursarina* have not been numerous, but have been increasing steadily in number for two or three years, at least, new forms continually appearing, while the forms previously observed continued to be seen, showing that the new forms are not casual and fleeting visitants, but permanent inhabitants of the lake-water. New representatives of other families and genera have also made their appearance, and others are continuing to appear.

For about the time named (two years) the municipal authorities of the city of Cleveland have pursued the practice of dumping into Lake Erie, at a point nine miles east of the city and eight miles from shore, all the garbage and night-soil from the city, amounting to a scow-load daily. This point was, after careful investigation, decided by the Board of Health to be so far from the water-works crib where the water-supply is taken, and in such a direction as to be free from all danger of affecting the water-supply. There have been rumors that the required distance has not always been reached before dumping the contents of the garbage-scows, and occasional instances of such dereliction have been proven, hence the increase in the number of the forms of the *Infusoria* and of their abundance suggests very forcibly the disagreeable query whether the dumping of such matter into the lake is not the direct cause of their appearance in the water-supply, not only by affording an admirably well-suited field for propagation but by diffusing them with their food-supply through the influence of currents and storms over a vastly larger area than is generally believed.

This problem, which I have had in mind since it was first proposed to utilize the lake as a dumping-ground for the city's refuse, is far from solved when we concede, as it seems to me we properly may, that most of these recently-appearing forms are propagated in the neighborhood of the dumping-ground, since it does not necessarily follow that the contamination of the water extends so far as the range of the organisms bred there. Still, the common presence in the water-supply of organisms known to be natural to waters abounding in decaying matter and which have only lately become numerous, when considered in connection with their probable source of emanation cannot but excite apprehension.

In weighing the evidence afforded by the profuse appearance of the particular forms under consideration due effect should be given to those wonderfully admirable laws of nature by which the propagation of this class of forms is governed. Gifted by an all-wise Providence with a power of reproduction which we can but faintly appreciate, these lowly forms are also to a considerable extent given a voluntary control of the process of reproduction, so much so that in some forms an individual which, if provided with a favorable habitat and food-supply, would live a considerable time without reproduction and then reproduce but in limited number, is able upon the sudden failure of food and threatened failure of its field of life to convert itself into germs which survive its own destruction and, after lying dormant for an indefinite period, when afforded a suitable field of life develop living force and resume again the course of life and reproduction. At the same time the process of reproduction in this class in its normal state keeps exact pace with the food-supply. In foul water saturated with the food of these organisms, no matter what the situation be, we invariably find them to abound, but we never find them to abound in water free from or but scantily supplied with their food. Their life-period being limited by their food-supply the failure of the food-supply or its rapid diminution is the signal for that mysterious process, not yet solved, the resolution into the enduring germs by which the survival of the species is secured notwithstanding such cataclysmal changes as we are unable, as relating to our own life, even faintly to conceive of.

Depending thus closely upon their food-supply for life and the power of reproduction, we should naturally expect the presence of these forms to indicate the presence of their proper food in comparative abundance. No body of natural water is wholly destitute of the food of these organisms, and doubtless their locomotive powers in such a body of water as Lake Erie might enable them to wander miles from the place of their origin, but attributing to them the habits common to their class we should expect their locomotive powers to be employed in seeking that locality in which their food existed in the greatest profusion. And this, if true, would rather confine them to the locality of the dumping-grounds, covering not more than three or four square miles, instead of diffusing them throughout the waters, unless their food in equal abundance is equally widely diffused, and if this be the true explanation of their appearance in the water-supply it indicates an unhealthy contamination of the water caused and directly brought about by the very public who must suffer its injurious effects.

As against this source of alarm may be cited, however, the increasing number of forms accredited with an exclusively pure habitat, such as certain *Polyzoa* and *Rotatoria*, and on the whole it may be doubted whether the increase in number of forms is not fully as great among those whose presence is most consistent with purity as among those whose presence would indicate impurity in the water.

A series of chemical analyses of the water at different points would throw much light on this subject; but none has been made, so far as I can learn, nor is it likely to be done, unless by private enterprise. Meanwhile, those interested in this subject, especially the microscopists, have but to wait and continue their watching, and hope for good results.

That a temporary exclusion of light, even of considerable duration, does not seriously check the activity of these microscopic forms of life, is evidenced by the fact that, when first taken, the filterings, after a sojourn of hours, even days in some cases, in the total darkness of the water-mains, they are in as full activity of life as they are ever observed. Indeed, with a few exceptions, all the organisms observed in the filterings from the lake-water are seen in active life. There are a few forms, not frequently seen, which are always found dead or inactive, while of a few forms nothing but fragments are ever seen in the filterings. Most prominent among these latter forms are certain *Entomostraca* and *Arachnida* of indeterminate genera and species, represented in the filterings by detached parts and fragments, such as jaws, legs, claws, etc. The reason for the appearance in the filterings of these fragments, which usually indicate forms of a larger size than any that are found entire or living, at the same time when living forms of the same families are abundant, is not entirely plain; the probability is that these fragments are from the excreta of fishes and other forms which prey upon the *Entomostraca*, etc., and in this opinion I am confirmed by having seen in the filterings fragments of what I felt sure was muscular fiber in a state of partial digestion, or at least thorough maceration.

In addition to the forms whose nature can be determined, there is always present in the water a considerable quantity of what can only be described as "flocculent matter," much of it being granular, and in a state of extremely fine division, and some of it being, no doubt, decomposed vegetable and animal matter. Many fragments are seen whose nature cannot be determined, and some organisms are seen which, although their nature is apparent, cannot be accurately figured.

In the plate accompanying this paper only such forms are figured as were seen in the complete state, or sufficiently complete for certain identification, and, with a few exceptions noted, no forms are figured which were not seen on more than one occasion. Forms from No. 1 to No. 72 were seen during both spring and summer, and those from No. 73 to No. 83 were seen only in summer, with a few perennial forms.

The description of the figures on the plate, so far as yet identified, is as follows, the same symbols previously used being adopted to indicate their comparative abundance, viz.:

† Abundant. One or more seen in nearly every sample from each gathering.
‡ Very abundant. Many seen in every sample from each gathering.
* Common. Seen in every gathering at least once.
° Not common. Seen in more than half the gatherings.
§ Rare. Seen in less than half the gatherings.
‖ Very rare. Very few seen during the whole period.

DESCRIPTION OF PLATE.

PLATE III.

Fig. 1 *Stentor* (*S. Mulleri?*) Attaches itself at will by posterior extremity of body. Swims rapidly through the water, and also glides slowly along, like *Chætonotus*. a. × 120 by ½ in; b. and c. × 230 by ¼ in. Only seen at long intervals. ‖

2 *Vorticella sp.* (?) In clusters of 6 to 30. a. by 1 in. × 65; b. by ¼ in. × 230. Excessively abundant for short periods. ‡

3 *Polyarthra platyptera.* × 120. * A detached "sword" of a different species (Plate III, fig. 82), is occasionally observed at all seasons; it is much larger and wider than in this species.

4 *Anuræa sp.* (?) With *ovum*. Has facetted back and four spines. The egg has much the appearance, except in color, of the free eggs. (No. 97, Plate VII., 1881.) It is possible that the bodies (fig. 1, Plate VII., 1881) which were supposed to be an encysted state of *Vorticella*, are mature ova of *Rotifera*, as the resemblance in the ova is close, except in shape; but it seems hardly possible that they could be produced in such immense numbers when the parent forms are so scarce. × 65. *

5 *Furcularia*(?) *sp.* Retracted but living. Most of the forms of the *Hydatinæa* observed are dead or inactive, so that it is frequently difficult to distinguish different forms. × 65. ‖

6 *Anuræa sp.* (?) With nearly hatched embryo; the cilia of both in active play; the parent very lively. × 65. b. side view; c. the young rotifer more protruded, different specimen. °

7 (?) A rotifer living but retracted; two or three seen at different times; occasional spasmodic movement of the internal parts, and slight movement of the neck. × 65 ‖

8 *Brachionus* (?) The carapace has a single central projection, which bends over in front. a. side view; b. ventral view; c. end view of front of carapace. The wheels of cilia when in motion were not seen to protrude beyond the horn, but are probably able to do so. Not very lively; the foot, however, is in almost constant motion. × 65. §

9 *Rotifer sp.* (?) Very active. a. side view; b. end view. X 65. °

10 (?) Cilia large and stout; vacuole large; swims very rapidly. X 230 by ¼ in.; variable in size. ‖

11 *Polyzoa sp.* (?) Tough and fleshy; always seen inactive and never more than two seen on one branch. First seen in August, 1881, again seen in May, 1882. X 65 §

12 *Gregariana sp.* (?) The inclosed bodies move actively about. °

13 *Macrobiotus sp.* (?) Full of bright refractive globules, the contents of stomach having wave-like motion; more frequently seen dead than alive. X 65; a. head. X 120. §

14 *Hydra fusca* (?) Young individual lately separated. a. mouth, on a slight protuberance. X 65; a. portion of tentacle. X 120; b. same. X 230; c. urticating filament by ⅛ in. °

15 *Chydorus Sphericus.* X 65. Very large helmet. °

16 *Daphnia sp.* (?) Much more abundant than *D. pulex*, and always with the long, serrated posterior spine. The helmet always pointed, and often very much larger than in the figure. A variety (?) with the helmet very much prolonged and curved is occasionally found. The tip of the helmet is figured at b.; a. *plumose seta of antenna.* X 230. At times this form is very abundant; always common.

17 *Acineta tuberosa.* X 65. a. tentacles X 230. °

18 *Kondylostoma sp.* (?) (or *Leucopheys*). Cilia only seen at ends of body, but probably extend whole length. X 65. ° A form observed by Dr. R. Dayton, much more twisted, but probably the same, is figured at No. 19, from his drawing.

20 *Himantophorus* (?) °

21 (?) Resembles No. 10, but has cilia smaller and much more numerous, and usually has the bud (?) *

22 *Cothurnia sp.* (?) Not seen except on *Melosira.* X 230. °

23 *Cothurnia sp.* (?) A longer and slender form, only seen free. X 230. °

24 *Vaginicola.* (?) Seen only on *Asterionella* and *Tabellaria.* X 230. °

25 (?) Very similar to No. 24, but is flattened, while No. 24 is not. Only on *Cyclops.* X 230. *

26 *Epipyxis.* (?) Frequently seen, but always dead. X 230. °

27 A dark olive green worm-like body with granular contents and large vacuole. Twists and bends slowly and continuously; no sucker seen. §

28 *Actinophrys sp.* (?) Has six lobes and a central granular body, about thirty tentacles on each lobe, each terminated by a knob. Some of the tentacles are longer than the diameter of the body. X 230. ‖

29 *Monad.* Frequently seen dividing. *M. attenuata.* (?) *

30 *Ceratium longicorne.* Excessively abundant at times. *

31 *Polyzoa. Paludicella Ehrenbergii.* Only seen in fragments of two or three cells and usually dead. X 120. *

32 *Rotifer vulgaris.* Very active. X 65; a. foot attached to cover. *

33 *Euglypha alveolata.* Different ages. (?) All of these forms are seen, the plain unarmed form most frequent. I consider them all stages of the perfect form d. X 120. *

34 *Tintinnus sp.* (?) These five forms, with every degree of intermediate shape, are found during spring, summer and fall, quite abundant at times. The form e. swims freely through the water, but none of the others have been seen to move. Yet I cannot but regard

these forms as progressive stages of the perfect form e. X 120. *

35 *Difflugia globulosa* varieties. These forms, of same size and outline, and with all shapes of mouth to the shell, are found about equally plentiful. I regard the shape of the mouth as of little specific value. X 230. *

36 (?) Most likely the carapace of some rotifer, but never seen with any contents save a small accumulation of sarcode granules and apparently decomposing. X 120. a. one corner X 230. Structure resembles *Hemiaulus.* §

37 *Arcelula vulgaris.* X 230. °

38 *Peridinium.* (?) Very minute; never seen to move, but appear filled with granular sarcode and the shell finely punctate. X 230. b. X 380. Showing thickness of the suture. °

39 (?) Has same reddish brown color and structure as No. 38, but no section or joint perceptible; dead. (?) X 230. °

40 Eggs of. (?) These bodies, of which three forms are shown, are at times extremely abundant, they are of a light red color, transparent, filled with globules of varying size, mostly highly refractive, and occasionally exhibit an internal pulsation. They are evidently destined for a long stay in their present condition; they remain alive for days in the live box but exhibit no changes, and all efforts by persistent watching to learn into what form they hatch or transform have failed. X 120. *

41 A germinating spore of. (?) Several seen at different times are all exactly alike. X 230. §

42 *Coniferous pollen* — Three forms. X 120. °

43 Spores of. °

44 *Scenedesmus obliquus.* Sometimes plentiful. *

45 *Gonium.* (?) X 230. *

46 *Pediastrum.* (?) Young frond? X 120. °

47 *Arthrodesmus sp.* (?) Frond perfectly flat. °

48 *Oscillatoria sp.* (?) °

49 Spore capsule of. (?) Dark olive green; contents granlar. X 120. §

50 Fertile filament of *Saprolegnia.* Spores mostly discharged; only one seen. X 230.

51 Shell of *Rhizopod.* (?) Dark yellow, smooth, thin. X120. ‖

52 (?) Yellowish brown, smooth, hollow and brittle. X 65. §

53 Shells of *Trinema acinus.* Smooth, of a light yellow color and with smooth mouth. X 230. °

54 *Cyphoderia sp* (?) Shell colorless and glassy ; smooth. X 230. °

55 The same. (?) All of this form were white and colorless, while those of the preceding shape were always yellow. X 230. °

56 *Anabœna* (?) Always seen in this state, as if undergoing cell division. X 230. *

57 *Nitzschia* (?) X 230 ‖

58 *Nitzschia sp* (?) X 230. °

59 *Nitzschia sigma var*(?) X 230. •

60 *Tryblionella levidensis* (?) X 230. °

61 *Tryblionella sp* (?) X 230. °

62 *Meridion constrictum* (?) X 230. °

63 *Gomphonema olivaceum* (?) X 230. °

64 *G. herculaneum* (?) X 230. °

65 *G. acuminatum var.*(?) X 230. °

66 *Navicula,* X 680. §

67 *N. cuspidata.* X 180. °

68 *N. sp* (?) X 230. °

69 *Surirella.* X 180. •

70 *Amphora ovalis* (*var. gracilis*?) X 230. °

71 *Amphora* (?) X 230. °

72 (?) Empty frond of desmid or empty shell of ? X 230. °

73 *Lacinularia ? sp* (?) All have the fleshy muscular lobe (for attachment ?). X 120 ; a. top view. °

74 *Stylonichia sp* (?) Cilia all over. Eight rigid, bristle-

like spines that can be protruded at will ; two eyes ; vacuoles, and two internal sphincter. × 65. c. fully extended, b. retracted, a. surface of posterior one-third of body when extended; slow-moving. *

75 *Kerona sp* (?) Has not the style-like filaments of No. 2; no eyes discoverable; bluish gray. × 65. b. retracted; surface alike all over. °

76 A remarkable rotifer; undescribed ; carapace cellular and rather dark-colored ; sides somewhat concave, widest in middle; a deep, plicate furrow across the back, near the middle, from which two deep central furrows and two shallower outer furrows extend to the posterior tip of the carapace. Carapace open on ventral side by a narrow opening to the middle. Foot large, strong, simple, folded forward, and usually retracted within the carapace. Two stout retractile horns on dorsal side of anterior end of body. Rotatory disk, simple (?), seldom protruded beyond the margin of the shell; gizzard near mouth. No eye seen. Very active and robust; length, .01 in. a,c lateral view, b. dorsal view, c. ventral view, d. frontal view, e. frontal view showing furrows on back. × 120. Only one specimen seen, July 4th, 1882. ‖

77 *Lynceus* (*camptocercus*) *macrourus.* × °

78 Young *Vorticella* (?) × 230, §

79 Cell of a *Cothurnia* or *Vaginicola*, with dentate margin. × 230. ‖

80 *Rattulus* (?) Constantly spreading apart the toes of the foot. × 120. §

81 *Peridinium sp.* (?) × 250. Living, but usually sluggish. °

82 Sword of a *Polyarthra.* × 230 Seen at all seasons, but only detached. °

83 Jaw of some species of *Entomostraca*, seen at all seasons. No species found living in the filterings has such a jaw. × 230. *

Of the forms figured on Plate VII. of the Proceedings of Society, 1881, the following were not observed at all during the period covered by the observations recorded in Plate III., herewith, viz.:

Figures 4, 5, 8, 10, 12, 14, 20, 21, 28, 29, 32, 33, 35, 37, 39, 41, 49, 64, 74, 75, 77, 80, 81, 82, 90, 92, 95, 96, 98, 99, 100, 101, 102, 103, 104, 106, 107, 108, 109, 111, 114, 118, 123, 124, 126, 127, 132, 133, 134, 135, 137, 139, 142, 143, 146, 147, 148, 150, 152, 154, 156, 158, 159, 161, 162, 164, 165, 166, 167, 168, 169, 170, 172, 176, 177, 178, 183, 185, 189, 190, 191, 192.

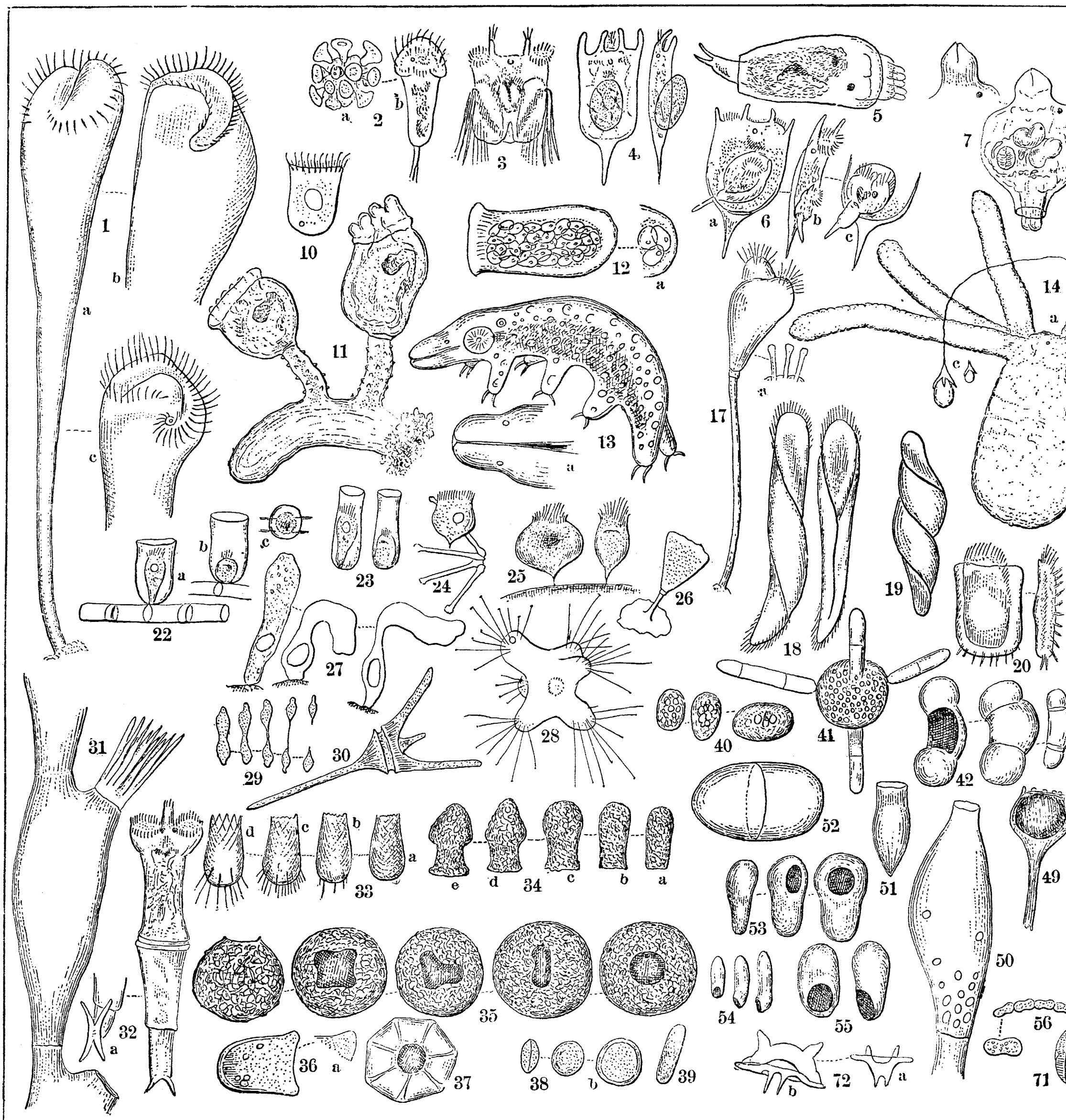
The following were observed in the spring only, before June 1st, in the relative abundance indicated, viz.: Figs. 1°, 2°, 6°, 11°, 15§, 16°, 17°, 23§, 24§, 27*, 40§, 42§, 61°, 113°, 117°, 119§, 125§, 128§, 129°, 141§, 144§, 149°, 151°, 153§, 155§, 163°, 173§, 174§, 179§, 182°, 184§.

The following were observed both in spring and summer, viz.: Figs. 3*, 7°, 9°, 13§, 18°, 19§, 22°, 25°, 30*, 31§, 34§, 36§, 38‖, 43°, 44°, 45°, 46§, 47§, 48°, 50*, 51°, 52§, 53°, 54§, 55*, 56*, 57°, 58°, 59*, 60*, 62*, 63°, 65*, 66*, 67°, 68°, 69§, 70§ 71§, 72§, 73°, 76§, 78§, 79§, 83‖, 84°, 85°, 87°, 89§, 91°, 93§, 94°, 97§, 112§, 115*, 116§, 120§, 121§, 122§, 130°, 131§, 136§, 138§, 140°, 145°, 157°, 160§, 171°, 175§, 181*, 186°, 187§, 188°.

The following were observed in summer only, after June 1st, viz.; Figs. 105‖, 110‖, 180‖.

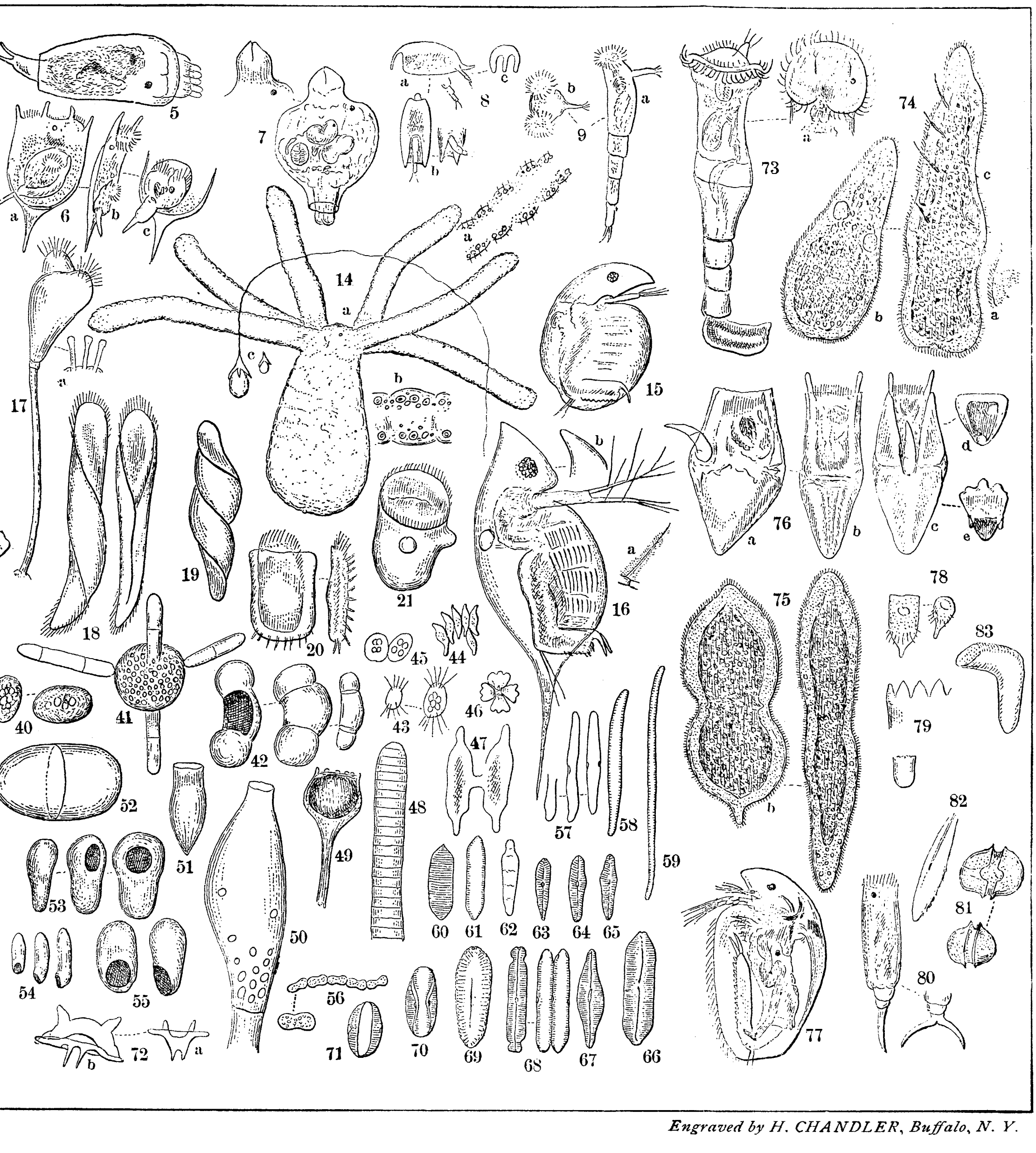
Of the forms figured on Plate III. the following are properly summer forms, being seen only late in spring, and much less frequently than in summer, viz.: Figs. 1, 5, 7, 11, 12, 14, 18, 31, 49, 50.

PLATE III.



C. M. VORCE, Del.

PLATE III.



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